Wearing a mask: a universal solution against COVID-19 or an additional health risk?

Christophe de Brouwer, MD, PhD
Honorary full-professor at the School of Public Health, Université libre de Bruxelles, Belgium.

Corresponding author: de.brouwer.christophe@ulb.ac.be

August 2020

Abstract

Wearing a mask is now attracting a lot of attention as a means of prevention against COVID-19 and many works have been published on this subject. Insofar as policy pressure or pressure from the media can lead to circumstance studies, it is also useful to examine the issue through work carried out before the current crisis. The image of the mask/respirator and its usefulness then takes on a rather different colour. It would appear that abstaining will often be more effective than wearing any "mask" without discernment. The principles of justification, optimization and limitation fully apply in this case.

Keywords: public health; prevention; face masks; health behaviour; COVID-19

JEL: I18

Letter to the editor.

Dear editor,

While the high-activity phase of the virus is behind us, several cities in France, Belgium and other countries have recently decided to impose wearing a mask both inside public places and outside.
Articles that have focused on the effectiveness of wearing a mask before the current crisis were fairly unanimous in their claim that it is useful in potentially infected environments, such as hospitals and other health care facilities, or for patients in a high viral pressure environment, but remained very cautious in other places, arguing a lack of evidence [1].
However, the World Health Organization (WHO) has amended its recommendations, following an article published in *The Lancet* on 5 June, 2020. This article has been commissioned and in part paid for by WHO [2]. Since what is commonly referred to as the "Lancet-gate" [3], it has become difficult to trust circumstance scientific articles. It is therefore important to examine also what the state of the issue concerning masks was before the COVID-19 crisis.

Masks in themselves can often be inadequate and dangerous, either because the material they are made from is not adequate or because the mask is poorly worn (which is very common). An often forgotten criterion, apart from the stopping power of the mask, is its breathability [4]. It should be remembered that coronavirus is a nanoparticle and is not stopped by the mesh of the mask, nor by impact, but by aggregation [5]. The nanoparticle diffuses by Brownian motion, it accompanies the airflow in all its meanders without deviating from it, except to aggregate.

The toxicology of nanoparticles was initially studied for the poliomyelitis virus, which is a relatively small virus (30 to 50 nanometres). The aim was to understand why this virus reached the central nervous system so easily.
This particular toxicology was rediscovered in the context of an "epidemic" of Parkinson's-type disease that affected (young) welders in the USA at the beginning of the 2000s; in other words, how the manganese contained in the welds reached the central nervous system. On that occasion, it was shown that the effective route of penetration of the toxic (virus) was not only the lungs, but the olfactory bulb on the ceiling of the nasal cavity [6].
The coronavirus is slightly larger than the poliovirus and smaller than the smallpox virus (100 to 150 nanometers) and with regard to tissue penetration, behaves like a nanoparticle.

It has been suggested that the risk of infection is related to microdroplets and fomites, however, how do micro-droplets behave in the air, given their high size/weight ratio? They will undergo a rapid desiccation that will reduce them almost to the size of the virus [7]. Inert particles or viruses of the same size have quite similar penetrating powers [8], therefore, there is no reason to consider other sizes than the size of the virus itself in the stopping power of a virus by a mask or a respirator.

For this reason, the problem of the mask/respirator is quite particular. At the very least, the FFP3 (N99) mask is recommended in the workplace to protect against viruses [9], however, the current recommendations for protection against COVID-19 do not propose the FFP3 respirator but rather the FFP2, or even a surgical mask, which poses an obvious problem of consistency [10].

In addition, the question about the ability of handmade cloth masks to stop nanoparticles can legitimately be raised, as research findings are divergent. They appear to stop between 80 to 20% of the particles or even less [11,12]. Do they become dangerous if they are not cleaned frequently? These cloth masks absorb moisture with breathing and when warmed up. A drop of saliva and other droplets melt into the hot moisture, causing an increased vapour pressure that inevitably collects many of the nanoparticles and microparticles. These will follow the movements of inhalation and exhalation, possibly infecting the wearer of the mask and his or her surroundings. In short, these masks can become dangerous, all the more so, as the virus can survive longer on these wet environments [13].

As for surgical masks, they stop nanoparticles at expiration in a proportion of about 80%; the first protection is the control of airflow in an operating room. They must be changed regularly, and in the best-case scenario, their use should not exceed 1 hour.

For respirators, protection is not absolute. They will let through 0.03 to 1 to 5% of the particles depending on the quality of the respirator [14]. The cleanliness of the material is essential. Here too, the wearing should not exceed half a day. This is already a lot considering the pressure drop inside the mask when it fits properly [15]. However, longer wear times are nowadays accepted as a response to the crisis, and they can be reused after cleaning (5 to 6 times maximum). So, in any case, ideally, it is certainly not worn all the time, nor the same, day after day.

So, let us summarize.
The stopping abilities of a half-face mask are related to the following:

- 1. To its fit on the face: leaks greatly reduce the mask's efficiency and can render inoperative the stopping capacity of nanoparticles that "exactly" follow the airflow (there is almost no inertia to the particles, which are too small and therefore it has no impact effect, as can be found for microparticles, bacteria for example). The problems of skin irritation and increased acne caused by the mask do not improve compliance for a "good wear" [16].
- 2. To the filtered quantity and therefore to the activity of the person wearing it, since the stopping power is not total: therefore, what is the effect of intense physical activity or rest-activity? In the first case, not only will saturation be quickly reached, but the number of nanoparticles that has crossed will be "significant", in the other case it is the opposite.
- 3. An important criterion, besides the stopping power, is breathability. This data is very present in studies prior to the crisis and shows that, for people with significant physical activity or people with impaired respiratory function (often the elderly), the mask/respirator not only brings significant discomfort but can also be a source of harm[17,18]. A hot ambient temperature could be an aggravating factor[19].
- 4. To the size of the nanoparticle and unfortunately, from this point of view, the 100 to 200 nm range is the one that penetrates best through the filters.
- 5. To the amount of nanoparticles present. As a mask/respirator lets a certain amount of nanoparticles through (0.03, to 1, to 5, to 20, to 50, to 80% or more, depending on the quality and condition of the mask/respirator, leaks, etc.), this implies a healthy environment. The hygiene of the premises is a major element; the protection factor related to the dilution of particles is essential.
- 6. To the speed of the infectious particle. Its penetration capacity increases with speed (during coughing, for example).

- 7. The time of exposure to infectious particles is, based on the same observations, is also essential.
- 8. To the behaviour. The fomites that bring the infectious particles to the mask that one touches more or less regularly with one’s fingers.
- 9. The defence capabilities of the organism play a key role, whether it be the passive and active defences of the respiratory tract, or the internal defences of the organism when an infectious particle has succeeded in passing through the olfactory bulb in particular. Smokers are more at risk from this point of view, and this is an example.

In short, wearing a mask usefully and effectively is not simple. Many factors play a role, including the intrinsic quality of the mask, the quality of the mask’s wearing, its renewal, the environment, the viral pressure, the degree of risk, etc.

There is no improvisation on this subject. Naive goodwill and unprofessional can be dangerous. It would appear that abstaining will often be more effective than wearing any “mask” without discernment. The principles of justification, optimization and limitation fully apply in this case.

Competing Interest Statement: No competing interest.

References :

1 WHO. *Advice on the use of masks in the context of COVID-19*. 6 april 2020. https://apps.who.int/iris/bitstream/handle/10665/331693/WHO-2019-nCov-IPC_Masks-2020.3-eng.pdf

2 Chu DK, Akl EA, Duda S, et al. P*hysical distancing, face masks, and eye protection to prevent person-to-person transmission of SARS-CoV-2 and COVID-19: a systematic review and meta-analysis*. Lancet. 2020;395(10242):1973-1987. doi:10.1016/S0140-6736(20)31142-9

3 Lancet. *Retraction—Hydroxychloroquine or chloroquine with or without a macrolide for treatment of COVID-19: a multinational registry analysis*. 5 juin 2020. doi:10.1016/S0140-6736(20)31324-6

4 WHO. *Advice on the use of masks in the context of COVID-19*. 5 June 2020. https://apps.who.int/iris/rest/bitstreams/1279750/retrieve

5 Oberdörster G, Oberdörster E, Oberdörster J. *Nanotoxicology: an emerging discipline evolving from studies of ultrafine particles* [published correction appears in Environ Health Perspect. 2010 Sep;118(9):A380]. Environ Health Perspect. 2005;113(7):823-839. doi:10.1289/ehp.7339

6 Sen S, Flynn MR, Du G, Tröster AI, An H, Huang X. *Manganese accumulation in the olfactory bulbs and other brain regions of "asymptomatic" welders*. Toxicol Sci. 2011;121(1):160-167. doi:10.1093/toxsci/kfr033

7 Eninger RM, Honda T, Adhikari A, Heinonen-Tanski H, Reponen T, Grinshpun SA. *Filter performance of n99 and n95 facepiece respirators against viruses and ultrafine particles*. Ann Occup Hyg. 2008;52(5):385-396. doi:10.1093/annhyg/men019

8 Morawska L. *Droplet fate in indoor environments, or can we prevent the spread of infection?* Indoor Air. 2006 Oct;16(5):335-47. doi: 10.1111/j.1600-0668.2006.00432.x.

9 HSE reports. *RR619 Evaluating the protection afforded by surgical masks*. 2008. https://www.hse.gov.uk/research/rrpdf/rr619.pdf

10 CDC. *Recommended Guidance for Extended Use and Limited Reuse of N95 Filtering Facepiece Respirators in Healthcare Settings*. 2018. https://www.cdc.gov/niosh/topics/hcwcontrols/recommendedguidanceextuse.html

11 Rengasamy S, Eimer B, Shaffer RE. *Simple respiratory protection--evaluation of the filtration performance of cloth masks and common fabric materials against 20-1000 nm size particles*. Ann Occup Hyg. 2010;54(7):789-798. doi:10.1093/annhyg/meq044

12 Cooper DW, HindsWC, Price JM. *Emergency respiratory protection with common materials*. Am Ind Hyg Assoc J. 1983;44:1-6.

13 Chen LD. *Effects of ambient temperature and humidity on droplet lifetime - A perspective of exhalation sneeze droplets with COVID-19 virus transmission* [published online ahead of print, 2020 Jun 5]. Int J Hyg Environ Health. 2020;229:113568. doi:10.1016/j.ijheh.2020.113568

14 O'Dowd K, Nair KM, Forouzandeh P, et al. *Face Masks and Respirators in the Fight against the COVID-19 Pandemic: A Review of Current Materials, Advances and Future Perspectives*. Materials (Basel). 2020;13(15):E3363. Published 2020 Jul 29. doi:10.3390/ma13153363

15 Penconek A, Drążyk P, Moskal A. *Penetration of diesel exhaust particles through commercially available dust half masks*. Ann Occup Hyg. 2013;57(3):360-373. doi:10.1093/annhyg/mes074

16 Hua W, Zuo Y, Wan R, et al. *Short-term skin reactions following use of N95 respirators and medical masks*. Contact Dermatitis. 2020;83(2):115-121. doi:10.1111/cod.13601

17 Roberge RJ, Coca A, Williams WJ, Powell JB, Palmiero AJ. *Physiological impact of the N95 filtering facepiece respirator on healthcare workers*. Respir Care. 2010;55(5):569-577.

18 Fikenzer S, Uhe T, Lavall D, et al. *Effects of surgical and FFP2/N95 face masks on cardiopulmonary exercise capacity* [published online ahead of print, 2020 Jul 6]. Clin Res Cardiol. 2020;1-9. doi:10.1007/s00392-020-01704-y

19 Fu SH, Gasparrini A, Rodriguez PS, Jha P. *Mortality attributable to hot and cold ambient temperatures in India: a nationally representative case-crossover study*. *PLoS Med*. 2018;15(7):e1002619. Published 2018 Jul 24. doi:10.1371/journal.pmed.1002619